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# Prevalence of kidney disease of unknown etiology in agricultural workers, Guatemala

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**ABSTRACT**

**Objectives.** To determine the prevalence of kidney disease of unknown etiology in banana, melon, and tomato workers in north-eastern Guatemala, and to evaluate the usefulness of a cystatin C blood test for early detection of renal disease.

**Methods.** This was a cross-sectional, farm-based study of 462 agricultural workers conducted from June to September 2021. Epidemiological and demographic characteristics of the workers were collected through a self-administered questionnaire. Blood samples were obtained to determine glucose, creatinine and cystatin C levels. Anthropometric and clinical data were also recorded.

**Results.** The prevalence of kidney disease of unknown etiology was 3.03% (95% confidence interval (CI): 1.36–4.70%) based on glomerular filtration rate (GFR-EPI) < 60 mL/min/1.73 $m^2$, with a significantly higher prevalence in banana workers (5.67%; 95% CI: 2.16–9.18%) than melon workers ($p$ = 0.009) and tomato workers ($p$ = 0.044). Ten workers (2.16%) had reduced kidney function (GFR-EPI 60–90 mL/min/1.73 $m^2$). The levels of cystatin C showed less variability (coefficient of variation 46.4%) than those of creatinine (coefficient of variation 67.0%), and cystatin C levels in cases with abnormal and reduced kidney function were significantly different from cases with normal kidney function ($p$ < 0.001).

**Conclusions.** Surveillance of the health of active farm workers and improvement of working conditions, such as sun protection, adequate hydration, and sufficient breaks, are recommended. The significant differences in cystatin C levels between cases with abnormal and reduced kidney function and those with normal kidney function suggest that cystatin C could be a useful measure for early detection of renal disease.

**Keywords** Kidney diseases; farm workers; glomerular filtration rate; Guatemala.

Chronic kidney disease of unknown etiology was first described in Central America in 2002 in a series of patients with terminal nephropathy without the traditional risk factors of advanced age, diabetes mellitus, or systemic arterial hypertension associated with cardiovascular disorders (1). Affected individuals were mainly young agricultural workers (1). Subsequently, a series of cases of nephropathy was reported in young male farmers working in the cultivation of sugarcane, in Costa Rica, Nicaragua, and Guatemala (2–5). Similarly, in other parts of the world, cases of chronic kidney disease that were not associated with traditional risk factors have been reported in agricultural workers, young people, and men (2). Studies of risk factors associated with the development of this disease have often indicated strenuous work, heat, and dehydration, which cause repeated episodes of acute kidney injury (6). Other factors that have been studied include pesticides, consumption of nonsteroidal anti-inflammatory drugs (NSAIDs), chronic exposure to metals, some infectious agents such as leptospirosis, and others (7, 8). More broadly, chronic kidney disease is considered a global epidemic that affects millions of people, especially people with diabetes and hypertension. The situation has worsened in Guatemala and Mesoamerica as result of the

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increasing number of patients suffering from chronic kidney disease of unknown etiology (9–11).

Reports on chronic kidney disease of unknown etiology have mainly included patients working in sugarcane cultivation; however, in Sri Lanka and North Africa, this disease has been linked to tobacco cultivation, environmental pollution, and abuse of medications (12, 13). Other agricultural activities that could increase the risk of developing chronic kidney disease of unknown etiology in Guatemala include the cultivation of bananas, melons, and tomatoes.

Chronic kidney disease is diagnosed by estimating the decrease in glomerular filtration rate (GFR) based on serum creatinine values, mainly using the GFR-EPI formula. This estimate includes sex, age, creatinine value, and ethnicity (African or other) (14).

The main objective of this study was to determine the prevalence of kidney disease of unknown etiology in agricultural laborers working in tomato, melon, and banana farms. We also evaluated the usefulness cystatin C as a screening tool for early detection of renal disease compared with creatinine values.

## METHODS

### Study setting and design

We conducted a cross-sectional survey in farms cultivating banana, melon, and tomato crops. These farms are in north-eastern Guatemala, in the departments of Izabal (banana), Zacapa (melon), and Chiquimula (tomato). Information on the number of workers was obtained from farm managers who also helped in the selection of field workers for the study. To determine the prevalence of kidney disease of unknown etiology, a sample was selected from the total of number of field workers. Clinical samples and epidemiological information were collected from the participating workers during visits to the selected farms from June to September 2021.

### Sample selection

Banana and melon farms are large-scale industries that hire large numbers of workers every year. In contrast, tomato farms are run on a smaller scale with a limited number of workers. The sample sized needed to allow statistical analysis of associated factors was 200 field workers per farm. Packaging plant workers and office workers were excluded. Inclusion criteria were: at least 1 year working with the company; aged between 18 and 60 years; and consent to participate. No sex distinction was made for selection of participants, however 98% of field workers were male and only 15 women were interviewed. Because of the small number, the women were excluded from the analysis.

### Biological samples and data collection

After giving their informed consent, study participants were interviewed at the farms. They completed a questionnaire on their epidemiological and sociodemographic characteristics, under supervision of the investigators. Blood pressure was measured once, but was measured again if abnormal values were found. An arm sphygmomanometer was used each time. Height and weight were recorded by the investigators using a stadiometer and a digital scale. A blood sample was obtained from all participants. Fasting glucose levels were measured in situ with an Accu-Chek Instant® (Roche, Indianapolis, USA), and sera were separated, frozen at –20 °C, and stored until further analysis.

### Serum analysis

Serum samples were used to determine creatinine and cystatin C levels. Creatinine was measured by the Jaffe reaction, and optical density readings were compared using a StatFax® (Awareness Technology, Inc., Palm City, USA) chemistry analyzer. Cystatin C was measured using a fluorescent immunoassay (IChroma®, Boditech Med Inc., Republic of Korea). Both measurements were performed by the authors at the laboratories of the Cytohistology Department of the Universidad de San Carlos de Guatemala.

### Working case definitions

GFRs were estimated using the creatinine and cystatin C values and the results were categorized using the KDIGO stages of kidney disease: normal kidney function (GFR-EPI > 90 mL/min/1.73 $m^2$); reduced kidney function equivalent to KDIGO stage G2 (GFR-EPI 60–90 mL/min/1.73 $m^2$); and abnormal kidney function equivalent to KDIGO stages G3, G4, and G5 (GFR-EPI < 60 mL/min/1.73 $m^2$).

Kidney disease associated with diabetes was considered when participants had abnormal kidney function and blood glucose > 140 mg/dL. Kidney disease associated with hypertension was considered when participants had abnormal kidney function and blood pressure > 140/90 mmHg according to the American Heart Association guidelines. Kidney disease of unknown etiology was considered when abnormal kidney function was established and neither diabetes nor hypertension was present. The results of the blood analysis were given to each participant. Individuals with abnormal results were referred to the farms' physicians or nephrologists in the nearest town for follow-up and treatment.

### Data analysis

Microsoft Excel (Microsoft, Redmond, USA) and XLSTAT (Lumivero, Denver, USA) were used for data analysis. Prevalence values were calculated with 95% confidence intervals (CI). A general linear model of covariance was used to evaluate the association of various factors on the GFR-EPI, with sociodemographic, clinical, occupational and behavioral characteristics. To evaluate the screening usefulness of cystatin C for early detection of renal disease compared with creatinine values, a one-way ANOVA test and a post-hoc Dunnett test were used to compare groups with reduced kidney function and abnormal kidney function against the group with normal kidney function.

### Ethical considerations

This study was approved by the Health Research Bioethics Committee of the Universidad de San Carlos de Guatemala (AC019-2020). All the participants provided written informed consent. Data obtained in this study were confidential

and only the investigators had access to the participants' information.

## RESULTS

A total of 462 workers were included in this study: 194 working on banana crops from Izabal, 194 working on melon crops from Zacapa, and 74 working on tomato crops from Chiquimula. Tomato cultivation is done in smaller farms with fewer workers per site, hence the lower number of these workers in our sample. The analysis excluded a small group of 15 women who did a range of jobs on the farms.

The mean (standard deviation (SD)) age of the workers was 36.8 (11.0) years and more than 95% were of mestizo ethnicity (term used to refer to a person of mixed European and indigenous American ancestry) (Table 1). Most of the workers had primary level education (54.5%), 37.3% had a secondary level education, while 3.5% could not read or write, and 4.7% had a university education. Mean (SD) height was 1.66 (0.07) m, weight was 75.7 (15.9) kg and BMI was 27.3 (4.7) kg/m$^2$. Most workers were either overweight (38.8%) or obese (26.4%).

The mean (SD) systolic pressure was 127.7 (12.8) mmHg and diastolic pressure was 78.6 (12.9) mmHg. Fifty-five (12.1%) workers were categorized as having hypertension (Table 1). Mean (SD) fasting glucose was 105.9 (41.7) mg/dL and 48 (10.9%) workers were considered to have diabetes. Mean (SD) creatinine was 1.15 (0.77) mg/dL, with a mean (SD) GFR-EPI creatinine of 89.2 (21.3) mL/min/1.73 m$^2$. Mean (SD) cystatin C was 0.84 (0.39) mg/dL with a mean (SD) GFR-EPI cystatin C of 108.4 (23.9) mL/min/1.73 m$^2$ (Table 1).

Occupational and behavioral characteristics of farmworkers are shown in Table 2. Participants reported a mean (SD) of 12.5 (9.3) years working on the farms, with an average (SD) workday of 8.4 (1.7) hours. The mean (SD) number of hours a day of work in the sun was 7.3 (1.8) hours and the median number of breaks a day was 2 (range 1–6). The mean (SD) duration of the breaks was 40.3 (28.1) min. Mean (SD) water consumption was 3.4 (1.3) L during a workday and 1.6 (1.5) L after work. The sources of drinking water were: purified water or filtered water for 111 (24.5%) participants and faucet or well water for 324 (71.7%) participants (Table 2).

Consumption of non-steroidal anti-inflammatory drugs (NSAIDs) was reported by 151 (34.2%) participants and 92 (44.2%) workers said they took these drug on a daily or weekly basis. As regards alcohol and tobacco use, 28.0% of the workers drank beer, 15.8% were current smokers, and 33.8% were former smokers. Energy drinks (Redbull®, Raptor®, and others) were consumed by 12.5% of the workers, carbonated water by

**TABLE 1. Sociodemographic and clinical characteristics of banana, melon, and tomato agricultural workers, Guatemala**

| Variable | Banana workers | Melon workers | Tomato workers | Total |
|---|---|---|---|---|
| | *n* = 194 | *n* = 194 | *n* = 69 | *n* = 457 |
| Age in years, mean (SD) | 37.9 (10.2) | 36.8 (10.7) | 33.4 (13.4) | 36.8 (11.0) |
| Ethnic group, n (%) | *n* = 184 | *n* = 186 | *n* = 67 | *n* = 437 |
| Mestizo | 179 (97.3) | 186 (100.0) | 64 (95.5) | 429 (98.2) |
| Other | 5 (2.7) | 0 (0) | 3 (4.5) | 8 (1.8) |
| Education, n (%) | *n* = 184 | *n* = 171 | *n* = 69 | *n* = 424 |
| No schooling | 3 (1.6) | 7 (4.1) | 5 (7.3) | 15 (3.5) |
| Primary school | 75 (40.8) | 108 (63.2) | 48 (69.6) | 231 (54.5) |
| High school | 91 (49.5) | 53 (31.0) | 14 (20.3) | 158 (37.3) |
| University | 15 (8.2) | 3 (1.8) | 2 (2.9) | 20 (4.7) |
| Height in m, mean (SD) | 1.67 (0.07) | 1.66 (0.07) | 1.64 (0.07) | 1.66 (0.07) |
| Weight in kg, mean (SD) | 78.8 (16.4) | 75.6 (15.7) | 67.8 (11.7) | 75.7 (15.9) |
| BMI in kg/m$^2$, mean (SD) | 28.0 (4.8) | 27.4 (4.8) | 25.0 (3.5) | 27.3 (4.7) |
| BMI status, n (%) | *n* = 194 | *n* = 194 | *n* = 71 | *n* = 459 |
| Underweight | 0 (0.0) | 0 (0.0) | 1 (1.4) | 1 (0.2) |
| Normal | 55 (28.4) | 66 (34.0) | 38 (53.5) | 159 (34.6) |
| Overweight | 81 (41.7) | 72 (37.1) | 25 (35.2) | 178 (38.8) |
| Obese | 58 (29.9) | 56 (28.9) | 7 (9.9) | 121 (26.4) |
| Blood pressure in mmHg, mean (SD) | | | | |
| Systolic | 131.2 (16.9) | 123.5 (15.9) | 128.4 (15.5) | 127.7 (12.8) |
| Diastolic | 85.7 (12.4) | 72.5 (10.9) | 74.1 (10.8) | 78.6 (12.9) |
| Hypertension, n/N (%) | 38/191 (19.9) | 14/193 (7.2) | 3/70 (4.3) | 55/454 (12.1) |
| Fasting glucose in mg/dL, mean (SD) | 95.7 (48.5) | 114.5 (37.9) | 11.4 (41.8) | 105.9 (41.7) |
| Diabetes mellitus, n/N (%) | 26/193 (13.5) | 21/192 (10.9) | 1/55 (1.8) | 48/440 (10.9) |
| Creatinine in mg/dL, mean (SD) | 1.28 (1.15) | 1.07 (0.22) | 1.01 (0.18) | 1.15 (0.77) |
| Cystatin C in mg/dL, mean (SD) | 0.91 (0.54) | 0.80 (0.21) | 0.78 (0.22) | 0.84 (0.39) |
| GFR-EPI creatinine in mL/min/1.73 m$^2$, mean (SD) | 83.0 (22.8) | 91.1 (18.4) | 100.7 (18.3) | 89.2 (21.3) |
| GFR-EPI cystatin C in mL/min/1.73 m$^2$, mean (SD) | 105.2 (28.9) | 107.7 (16.5) | 118.6 (23.6) | 108.4 (23.9) |

SD, standard deviation; BMI, body mass index; GFR-EPI, glomerular filtration rate epidemiology collaboration.
***Source:*** prepared by authors from the results.

**TABLE 2. Occupational and behavioral characteristics of banana, melon, and tomato agricultural workers, Guatemala**

| Variable | Banana workers | Melon workers | Tomato workers | Total |
|---|---|---|---|---|
| Time of working on farms in years, Mean (SD) | 15.2 (9.7) | 10.9 (8.0) | 9.1 (9.7) | 12.5 (9.3) |
| Length of working day in hours, Mean (SD) | 9.0 (2.3) | 8.0 (0.2) | 7.4 (1.2) | 8.4 (1.7) |
| Time working under the sun a day in hours, Mean (SD) | 7.6 (2.0) | 7.3 (1.4) | 6.9 (1.8) | 7.3 (1.8) |
| No. of breaks, median (range) | 1 (1–6) | 2 (1–4) | 1 (1–4) | 2 (1–6) |
| Duration of breaks in min, Mean (SD) | 19.7 (16.2) | 62 (24.4) | 38.5 (28.1) | 40.3 (28.1) |
| Water consumed in work day in L, Mean (SD) | 3.0 (1.2) | 3.8 (1.2) | 3.2 (1.5) | 3.4 (1.3) |
| Water consumed after work in L, Mean (SD) | 1.5 (1.4) | 1.9 (1.7)[c] | 1.2 (0.9) | 1.6 (1.5) |
| Consumption of NSAIDs, n/N (%) | 54/191 (28.3) | 64/179 (35.7) | 33/71 (46.5) | 151/441 (34.2) |
| Frequency of analgesic use (daily or weekly), n/N (%) | 42/81 (51.8) | 33/83 (39.8) | 17/44 (38.6) | 92/208 (44.2) |
| Beer consumption, n/N (%) | 58/187 (31.0) | 36/172 (20.9) | 27/73 (37.0) | 121/432 (28.0) |
| Current smoker, n/N (%) | 22/186 (11.8) | 26/173 (15.0) | 20/71 (28.2) | 68/430 (15.8) |
| Smoked in the past, n/N (%) | 61/175 (34.9) | 48/163 (29.4) | 27/64 (42.2) | 136/402 (33.8) |
| Beverages consumed, n/N (%) | | | | |
| Energy drinks | 23/179 (12.8) | 11/174 (6.3) | 19/71 (26.8) | 53/424 (12.5) |
| Soda | 17/179 (9.5) | 4/174 (2.5) | 2/71 (2.8) | 23/424 (5.4) |
| Hydrating drinks | 56/179 (31.3) | 69/174 (39.7) | 15/71 (21.1) | 140/424 (33.0) |
| Source of drinking water, n/N (%) | | | | |
| Purified or filtered water | 77/189 (40.8) | 29/190 (15.3) | 5/73 (6.8) | 111/452 (24.5) |
| Faucet or well water | 101/189 (53.4) | 157/190 (82.6) | 66/73 (90.4) | 324/452 (71.7) |

SD, standard deviation; NSAIDs, non-steroidal anti-inflammatory drugs.
***Source:*** prepared by authors from the results.

5.4%, and hydrating drinks (Gatorade® and oral rehydration salts) by 33.0% (Table 2).

Based on biomarkers of renal disease (creatinine and cystatin C levels) and corresponding GFR (GFR-EPI), 24 (5.2%) workers had abnormal kidney function of any etiology. Of these workers, 5 (1.1%) were categorized as having kidney disease due to diabetes mellitus, 5 (1.1%) due to hypertension and 14 (3.1%) with kidney disease of unknown etiology. Because few workers had abnormal kidney function, we could not evaluate differences between these groups.

When workers with reduced kidney function (GFR-EPI 60–90 mL/min/1.73 $m^2$) were included, the prevalence of kidney disease overall increased to 38 individuals (8.2%) – 6 (1.3%) workers with kidney disease caused by diabetes mellitus, 8 (1.7%) with kidney disease caused by hypertension and 24 (5.2%) with kidney disease of unknown etiology. The prevalence of kidney disease was higher in banana workers than melon workers ($p$ = 0.0009) and tomato workers ($p$ = 0.0447) (Table 3).

When the general linear model of covariance was prepared based on 239 individuals, reduced GFR-EPI cystatin C was associated with longer time of working on farms ($p$ = 0.011), elevated levels of C-reactive protein ($p$ = 0.007), and elevated levels of serum creatinine ($p < 0.001$). To compare the performance of creatinine and cystatin C as blood tests for renal function, the overall cystatin C coefficient of variation was 46.4%, lower than that of creatinine, with a coefficient of variation of 67.0%. The one-way ANOVA and Dunnett tests showed that serum levels of cystatin C in cases of both reduced and abnormal kidney function differed significantly from levels in cases with normal kidney function ($p < 0.001$) (Figure 1). Serum levels of creatinine did not differ significantly from normal kidney function for reduced kidney function ($p$ = 0.905) but differed significantly for abnormal kidney function ($p < 0.001$) (Figure 1).

## DISCUSSION

Chronic kidney disease of non-traditional cause has been reported mainly in agricultural workers engaged in sugarcane cutting, however, little is known about its prevalence in other types of agricultural worker (4, 5, 15). In this study, we report the prevalence of kidney disease, clinical and sociodemographic characteristics, and occupational and behavioral characteristics in banana, melon and tomato agricultural workers in Guatemala.

The prevalence of kidney disease of unknown etiology found in individuals with abnormal kidney function working in banana, melon and tomato farms was 3.0%, which is lower than that reported for workers engaged in the cutting of sugarcane on the south coast of Guatemala by Sorensen et al. (4.6%), and that reported by Miller et al. in workers in Suchitepéquez (6.9%) (Table 4) (16, 17). Our results were lower when we included individuals with reduced kidney function for comparison. Differences in population health may explain some of the differences between our results and those in the Miller and colleagues study, which included individuals with a history of diabetes mellitus and high blood pressure (17). The results reported by Miller et al. for the Chimaltenango region, in the Guatemalan highlands, were lower for abnormal kidney function, but higher when comparing individuals with reduced kidney function. The differences found could be because of geographic and climate differences in exposure to heat, dehydration, and other risk factors (Table 4)

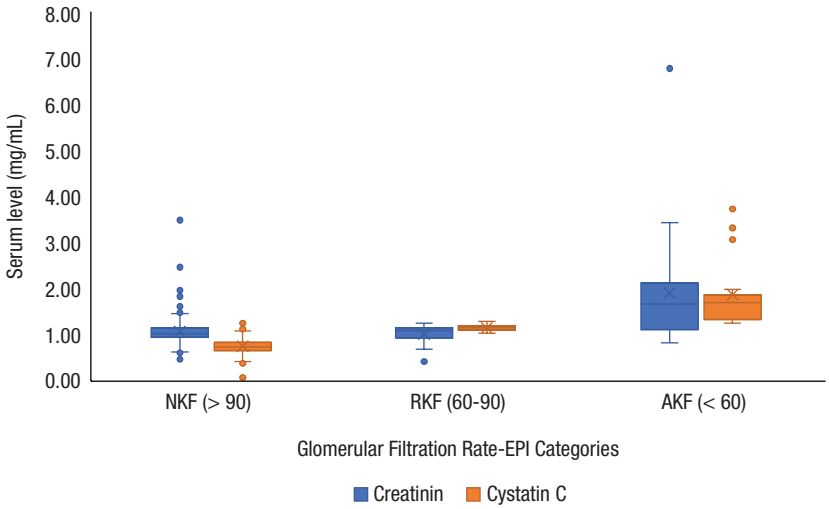
The prevalence of kidney disease of unknown etiology in our study cannot be compared with the frequency of the disease at the national level, since the National Registry of Dialysis and Transplants has not yet published the updated results for 2021 and in 2019 (last report), kidney disease of unknown etiology was not counted (18).

**TABLE 3. Etiology and prevalence of kidney disease in banana, melon, and tomato agricultural workers, Guatemala**

| Etiology of chronic kidney disease | Banana workers | Melon workers | Tomato workers | Total |
|---|---|---|---|---|
| Chronic kidney disease associated with diabetes mellitus, n (%); (95% CI) | | | | |
| Reduced kidney function | 0 (0.00); (NA) | 1 (0.52); (0.01–2.84) | 0 (0.00); (NA) | 1 (0.22); (0.01–1.20) |
| Abnormal kidney function | 3 (1.55); (0.32–4.45)[e] | 1 (0.52); | 1 (1.35); (0.03–7.30) | 5 (1.08); (0.35–2.51) |
| Chronic kidney disease associated with high blood pressure, n (%); (95% CI) | | | | |
| Reduced kidney function | 3 (1.55); (0.32–4.45) | 0 (0.00); (NA) | 0 (0.00); (NA) | 3 (0.65); (0.13–1.89) |
| Abnormal kidney function | 3 (1.55); (0.32–4.45) | 1 (0.52); (0.01–2.84) | 1 (1.35); (0.03–7.30) | 5 (1.08); (0.35–2.51) |
| Chronic kidney disease, n (%); 95% (CI) | | | | |
| Reduced kidney function | 6 (3.09); (0.40–5.79) | 2 (1.03); (0.12–3.67)[a] | 2 (2.70); (0.33–9.42)[b] | 10 (2.16); (¨ 0.73–3.60) |
| Abnormal kidney function | 11 (5.67); (2.16–9.18) | 3 (1.55); (0.32–4.45) | 0 (0.00); (NA) | 14 (3.03); (1.36–4.70) |
| Normal kidney function, n (%) | 168 (86.60) | 186 (95.88) | 70 (94.59) | 424 (91.77) |
| **Total, n (%)** | **194 (100.00)** | **194 (100.00)** | **74 (100.00)** | **462 (100.00)** |

CI, confidence interval; NA, not applicable.
***Source:*** prepared by authors from the results.
[a] $p = 0.0009$, comparing kidney disease in banana and melon workers.
[b] $p = 0.0447$, comparing kidney disease in banana and tomato workers.

**FIGURE 1. Creatinine and cystatin C levels by kidney function in agricultural workers, Guatemala**




NKF, normal kidney function; RKF, reduced kidney function; AKF, abnormal kidney function.
***Source:*** prepared by authors from the results.

The prevalence rates of kidney disease in laborers working with different crops (bananas in Izabal, melons in Zacapa, and tomatoes in Chiquimula) were different. The prevalence in banana workers was higher (13.40%), than melon (4.12%) and tomato (5.41%) workers ($p = 0.0009$ and $p = 0.045$, respectively). The prevalence of kidney disease of unknown etiology was also higher in banana workers than melon workers ($p = 0.016$) but not tomato workers ($p = 0.144$).

Although our study was not designed to investigate climate and environmental conditions in the three departments, as a general observation, conditions differ, especially with regard to relative humidity (data not presented) in Izabal. We speculate that this risk factor may help explain differences in the three crops reported in a study in northern Mexico (19), which showed that exposure to heat is one of the most important factors in the deterioration of renal function in agricultural workers (6, 7, 19). There are other risk factors, such as exposure to agrochemicals and metals, dehydration and acute kidney damage during working hours, and unhealthy lifestyle, which in a multifactorial disease such as kidney disease are difficult to clearly demonstrate (4, 5, 16, 17, 19).

The main risk factor associated with the development of chronic kidney disease is heat stress during agricultural work activities (6). The departments in which the participating farms are located experience some of the highest temperatures in Guatemala, especially Zacapa and Chiquimula. The prevalence of chronic kidney disease observed in our study was lower than that on the south coast (16), possibly indicating the presence of other risk factors, such as the nature of the labor exposing workers to a more strenuous

**TABLE 4. Prevalence of chronic kidney disease in agricultural workers, Guatemala**

| Study (population) | Kidney function | n (%) |
|---|---|---|
| Sorensen et al, 2020 (16)[a] (sugarcane workers) | Total | 483 (100) |
| | Reduced kidney function | 70 (14.5) |
| | Abnormal kidney function | 22 (4.6) |
| | Normal kidney function | 391 (80.9) |
| Miller et al, 2021(17)[b] (mixed agricultural activities, mostly corn and vegetables) | Total | 405 (100) |
| | Tecpán | |
| | Abnormal kidney function | 11 (2.7) |
| | Reduced kidney function | 92 (22.7) |
| | Suchitepéquez | |
| | Abnormal kidney function | 28 (6.9) |
| | Reduced kidney function | 66 (16.3) |
| Arroyo et al, 2023[c] (banana, melon, and tomato workers) | Total | 462 (100) |
| | Reduced kidney function | 10 (2.2) |
| | Abnormal kidney function | 14 (3.0) |

[a] Cross-sectional study.
[b] Population-based study; male and female workers included.
[c] Present study.
***Note:*** Abnormal kidney function = glomerular filtration rate epidemiology collaboration < 60 mL/min per 1.73 $m^2$; reduced kidney function = glomerular filtration rate epidemiology collaboration >60–< 90 mL/min/1.73 $m^2$.
***Source:*** prepared by authors.

work, personal behavior or environmental behavior including possible exposure to other risk factors such as metals or pesticide residues.

The prevalence rates of other chronic diseases evaluated in this study (diabetes mellitus and hypertension) were comparable to those reported by the National Survey of Chronic Noncommunicable Diseases and their risk factors (20). The prevalence of hypertension reported for persons older than 18 years was 16.6% (95% CI: 12.7–19.3%) and that found in our study was 12.0%. Similarly, the prevalence of diabetes mellitus reported in the national survey was 7.0% (95% CI: 5.0–9.1%) and that found in this study was 10.9%, indicating the high frequency of coexistence of chronic noncommunicable diseases in Guatemala (20).

The mean age was comparable in the workers of the three types of farm. Education level was also comparable with more than 50% of the workers with at least a primary level education. High proportions of the workers were overweight (38.8%) or obese (26.4%), which concurs with data reported by the Ministry of Health and Social Assistance in its latest survey of chronic noncommunicable diseases and their risk factors (20).

Our participants regularly worked more than 8 hours a day, mostly in the sun, which favors heat stress and possibly episodes of acute kidney injury. Repeated episodes of acute kidney injury have been associated with persistent kidney injury. Adequate breaks during the working day, duration of breaks and consumption of water should be considered to improve hydration and reduce exposure to heat, especially during the hottest hours of the day. The use of rehydration salts has been shown to be well tolerated and contributes to reduction of kidney damage (5, 21–23).

Agricultural work in extreme heat conditions is strenuous and may contribute to excessive reliance on painkillers. The routine use of NSAIDs is also a risk factor for kidney damage, and 34.2% (151/441) of the workers in our study took these drugs and 44.2% (92/208) took them on a daily or weekly basis. Sale of NSAIDs without a medical prescription in stores and pharmacies is a possible risk for the development of kidney disease. Regulation of over-the-counter dispensing and control of NSAID advertising could contribute to reducing the risk of kidney disease (5).

Tobacco use is a risk factors for kidney disease and 15.8% of the workers in our study said they were current smokers and 33.8% smoked in the past. This is based on self-reports of the workers, but recent studies indicate that such self-reporting significantly underestimates the consumption of cigarettes, so it is likely that the consumption is higher (24).

Consumption of carbonated and energizing beverages has also been suggested as a possible risk factor for kidney disease. Several studies have concluded that dietary intake of sugar-sweetened beverages increases the risk of chronic kidney disease, as well as causing high uric acid levels, obesity and increased risk of diabetes (25–27). In this study, consumption of carbonated and energizing drinks was low (5.4% and 12.5%, respectively), but the consumption of hydrating drinks was considerably higher (33.0%). As regards water consumption, 61.7% of the workers drank water from the faucet or a well; however, microbiological analysis of such water in the tomato farms showed that it was not suitable for human consumption due to the presence of total coliforms and *Escherichia coli*, at higher levels than accepted standards.

The significant differences in cystatin C levels between cases with abnormal and reduced kidney function and those with normal kidney function suggest cystatin C would be a useful measure for early detection of renal disease.

Our study has some limitations. As it was a cross-sectional study, it depended on opportunistic sampling of workers in the banana and melon farms, which was enabled by the managers and administrative staff. To facilitate participation of workers, most volunteers lived close to the packing plants which may have introduced bias. Self-reporting demographic and social characteristics may also have introduced bias, hence limiting the generalizability of our findings. Although the research team

supervised the data collection, information was missing in the survey which may also have affected our results.

## Conclusion

The prevalence of kidney disease found in banana, melon, and tomato agricultural workers was 5.2% and the prevalence of kidney disease of unknown etiology was 3.0%. Banana workers had a higher prevalence of kidney disease of unknown etiology (5.7%). Cystatin C could detect low levels of GFR-EPI earlier than creatinine, especially in cases with GFR-EPI 90–60 ml/min/1.73 $m^2$.

Surveillance of the health of active farm workers and improvement of working conditions, such as sun protection, and adequate hydration and breaks, are recommended. In addition, these workers should be educated and encouraged to adopt healthier ways of life, such as avoidance of carbonated soft drinks and frequent use of NSAIDs.

**Authors' contributions.** JP, GS, SG, and MD-M helped plan the study and collected data. PB, BA, and AC collected and processed biological samples. FN planned the study, analyzed and interpreted the results, and contributed to writing the manuscript. GA coordinated the team of investigators, participated in each phase of the project, and wrote the final manuscript. All authors reviewed and approved the final version.

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**Conflicts of interest.** None declared.

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## Prevalencia de la nefropatía de etiología desconocida en el personal del sector agrícola de Guatemala

**RESUMEN**

**Objetivos.** Determinar la prevalencia de la nefropatía de etiología desconocida en el personal de los sectores de la banana, el melón y el tomate en el noreste de Guatemala, así como la utilidad de un análisis de la cistatina C en sangre para su detección temprana.

**Métodos.** Se llevó a cabo un estudio transversal en 462 personas que trabajan en establecimientos agrícolas entre junio y septiembre del 2021. Se utilizaron cuestionarios rellenados por las propias personas encuestadas a fin de recopilar sus características epidemiológicas y demográficas. Se tomaron muestras de sangre para determinar las concentraciones de glucosa, creatinina y cistatina C. También se obtuvieron datos antropométricos y clínicos.

**Resultados.** La prevalencia de la nefropatía de etiología desconocida, definida por una filtración glomerular (determinada con la fórmula GRF—EPI) <60 ml/min/1,73 $m^2$, fue del 3,03% (intervalo de confianza [IC] del 95%: 1,36–4,70%); y la cifra fue significativamente mayor en el personal del sector de la banana (5,67%; IC 95%: 2,16–9,18%) que en el de los sectores del melón (p = 0,009) y del tomate (p = 0,044). Diez personas (2,16%) presentaron una reducción de la función renal (GRF—EPI 60—90 ml/min/1,73 $m^2$). Se observó una menor variabilidad en las concentraciones de cistatina C (coeficiente de variación del 46,4%) que en las de creatinina (coeficiente de variación del 67,0%); asimismo, hubo una diferencia significativa (p <0,001) de las concentraciones de cistatina C entre las personas con un valor anormal o una reducción de la función y las que tenían una función renal normal.

**Conclusiones.** Se recomienda la vigilancia de la salud del personal laboral del sector agrícola y la mejora de sus condiciones de trabajo, por ejemplo mediante la protección frente a la luz solar, una hidratación adecuada y un número suficiente de pausas en el trabajo. Las diferencias significativas en las concentraciones de cistatina C entre las personas con una función renal alterada o reducida y las personas con una función renal normal hacen pensar que la determinación de la cistatina C podría ser un parámetro útil para la detección precoz de la nefropatía.

**Palabras clave** Enfermedades renales; agricultores; tasa de filtración glomerular; Guatemala.

# Prevalência de doença renal de etiologia desconhecida em trabalhadores agrícolas na Guatemala

**RESUMO**

**Objetivos.** Determinar a prevalência de doença renal de etiologia desconhecida em trabalhadores que cultivam banana, melão e tomate no nordeste da Guatemala e avaliar a utilidade da dosagem sanguínea de cistatina C para detecção precoce de doença renal.

**Métodos.** Estudo transversal realizado de junho a setembro de 2021 com 462 trabalhadores rurais em unidades produtoras agrícolas. As características epidemiológicas e demográficas dos trabalhadores foram coletadas por meio de um questionário autoadministrado. Foram obtidas amostras de sangue para dosagem de glicose, creatinina e cistatina C. Os dados antropométricos e clínicos também foram registrados.

**Resultados.** A prevalência da doença renal de etiologia desconhecida foi de 3,03% (intervalo de confiança (IC) de 95%: 1,36-4,70%), com base em uma taxa de filtração glomerular (TFG-EPI) < 60 mL/min/1,73 $m^2$. A prevalência foi significantemente maior em cultivadores de banana (5,67%; IC de 95%: 2,16-9,18%) do que em cultivadores de melão ($p = 0,009$) e de tomate ($p = 0,044$). Dez trabalhadores (2,16%) tinham função renal reduzida (TFG-EPI 60-90 mL/min/1,73 $m^2$). Os níveis de cistatina C foram menos variáveis (coeficiente de variação: 46,4%) que os de creatinina (coeficiente de variação: 67,0%). Os níveis de cistatina C foram significantemente diferentes entre casos com função renal alterada ou reduzida e casos com função renal normal ($p < 0,001$).

**Conclusões.** Recomenda-se a vigilância da saúde dos trabalhadores rurais ativos e a melhoria das condições de trabalho, como proteção contra o sol, hidratação adequada e intervalos de descanso suficientes. As diferenças significantes nos níveis de cistatina C entre trabalhadores com função renal alterada ou reduzida e trabalhadores com função renal normal sugerem que a cistatina C poderia ser uma medida útil para a detecção precoce da doença renal.

**Palavras-chave** Nefropatias; fazendeiros; taxa de filtração glomerular; Guatemala.